RESEARCH ON WHEAT FERTILIZATION

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Introduction

The main wheat producing areas in South Africa are the Orange Free State and the Cape Province, which together account for 80% of the total area under wheat, viz approximately 1,9 million hectares.

In the Orange Free State wheat is grown in virtually every district, while in the Cape Province most of the wheat is grown in the Swartland (South-Western Cape) and the Rûens (Southern Cape).

In both provinces wheat is sown in late autumn or winter. The main difference in growing conditions being that in the Orange Free State conserved moisture has to sustain the wheat through a three to five month dry period, while in the Cape winter rainfall must carry the wheat through. As the soils in the Cape are generally shallow, the rainfall distribution throughout the season is important.

This dependence on rainfall, be it in summer in the Orange Free State or in winter in the Cape, emphasizes the need for good field husbandry.

Wheat production and consumption

The precarious position as far as supply and demand is concerned is shown in Table 1.

TABLE 1: Area under wheat, production and internal consumption

Season	Area in million ha	Bought by Wheat Board (production)	Internal Surplus consumption million/ton	
1975	1,84	1,74	1,74	0
1976	1,94	2,17	1,66	0,51
1977	1,79	1,79	1,63	0,16
1978	1,88	1,50	1,73	0,23
1979	1,90	2,03	1,76	0,27
1980	1,62	1,38	1,90	0,52

(Source: Division of Agricultural Marketing Research and Wheat Board)

(i) The largest area was 1,94 million ha and recently the smallest 1,62 million ha, which constitutes a reduction of 16%.

(ii) As far as internal consumption is concerned the largest difference from year to year was 14%.

(iii) However, production (bought by the Wheat Board) has varied by as much as 36% over the six-year period shown in Table 1.

(iv) Due to variations in production, surplusses and shortages occur haphazardly. On average over the last six years there was a surplus of 30 000 tons, which means that theoretically the needs of the country can be met. However, this will only be the case if in years of overproduction storage space can be found and financed. The alternative of export and import is also not an ideal solution as South African wheat is a poor competitor on world grain markets.

The position at the moment is therefore, that the country is more or less selfsupporting. The question arises, whether we can sustain this position, if the internal consumption continues to increase at the same annual rate of approximately 3 per cent as during the last five years.

Yield

In Table 2 the mean yield in kg/ha for the different areas and the mean production and consumption for the whole of the Republic over the five-year period 1976 - 1980 is shown.

TABLE 2: Wheat yields in the production areas of the RSA, 1976 - 1980

Area	Mean yield in kg/ha	Production (from Table 1)	Consumption
Eastern OFS	1321		
Orange Free State	1097		
Swartland	1087		
Rûens	1219		
Cape Province	760		
Republic	1045	1,77	1,74

By the year 2000 the production will have to be increased by at least 60 per cent to 3,04 million tons to keep pace with internal demand. However, it is more likely that the annual increase in consumption will be more than 3 per cent in the years to come. Therefore, it might be safer to anticipate that the internal requirements of 1980 must be doubled to provide for the needs by the year 2000.

As horizontal expansion will be limited, the yields per ha will virtually have to be doubled to produce the wheat required. This means a yield per ha for the whole of the Republic of approximately 200 kg.

Factors Limiting Production

As is the case with any other crop, the following factors must be improved upon and perhaps even optimized.

(i) Soil preparation for maximum water absorption and preservation of optimum root zone conditions.

(ii) Proper sowing (planting) equipment to ensure an even stand of plants. At this stage there is a lack of machines

which can place seed more or less equidistant in the rows and apply fertilizer at the required depth in the soil.

Moreover the size of areas to be planted (sown) and the limited time available lead, in many cases, to a lack of adequate calibration of seed and fertilizer at regular intervals and result in planting taking place at excessive speeds.

(iii) Cultivars should be appropriate for the various planting times.

The two organisations involved in wheat breeding (Small Grain Centre at Bethlehem and Sensako) have in the past brought onto the market cultivars of which the full potential has not yet been exploited.

(iv) Seeding rate is a factor which has not been investigated to the full in the areas where it may play a vital role, especially in the Orange Free State.

It would appear that the quantities of seed used are in many instances too high, preventing the plants from stooling to their full potential.

(v) Weeds, diseases and insects reduce yields and should be effectively yet economically monitored and controlled. Knowledge of the weed, disease or insect involved and the correct product and time of application to control it, if possible, are important.

(vi) Wheat is fairly tolerant of acidity but as it is usually grown in crop rotations it is advisable to maintain the pH(KCl) between 4,5 and 5,0.

(vii) Fertilization experiments have received little attention apart from work corrections by Mr A Hamman in the Eastern Free State until 1976. In that year the Small Grain Centre and the Vrystaat Koöperasie (in co-operation with the Fertilizer Society) started NPK experiments on a limited scale.
As from 1978 the Fertilizer Society established a post for work on the fertilization on wheat.

Co-ordination

All these points need attention as not nearly enough is known about them. The problems are complicated by the fact that conditions change over short distances, requiring different approaches for optimum production.

From the above it is quite clear that only co-ordination with other bodies and a directed sharing of the responsibilities can lead towards the solution of existing problem areas.

Duplication of work and a half-hearted approach will not only be wasteful, but will result in failing to achieve the stated aim with dire consequences. The only way to success is through co-operation by all concerned.

The fertilization aspect is the prime objective of the Fertilizer Society. But, as fertilizer can only increase wheat yields when the other production factors are as close to the optimum as possible, it is necessary to gather as much knowledge as possible with regard to these factors. In this respect the knowledge and experience of the agronomists of member companies, co-operative organisations and farmers are invaluable.

Fertilization

The co-ordination of work carried out by the Small Grain Centre and the Fertilizer Society since 1978 has borne fruit. The original fertilizer recommendations for the Orange Free State have been drastically increased as a result of the research, and are being discussed every year. Furthermore the programmes of the two institutions are arranged in such a manner that duplication does not occur.

In wheat fertilization, nitrogen is the element which warrants most attention. The reason for this is that wheat is planted or sown at different times of year, in widely separated areas on vastly different soils and under very different conditions, as shown in Table 3.

TABLE 3: Conditions in wheat growing areas in the RSA

Area	Predominant soil forms	Planting (sowing) date	Moisture regime
Cape: Swartland Rûens	Mispa Glen Rosa Swartland	May	winter rain
Orange Free State	Hutton Avalon Clovelly Westleigh	April May June	conserved moisture (summer rain)
Transvaal: Springbok Flats	Arcadia Shortlands	February	conserved moisture + autumn rains

Consequently the quantity as well as time and method of application of N depends upon the time of the year the seed goes into the soil and on the yield potentional.

The choice of cultivar as well as its nitrogen requirements depends upon the time of year and area in which it is to be grown.

In the Orange Free State the time of planting gets later as one moves from West to East. This is because the rainfall ceases at an earlier date in the West, causing the soil to start losing moisture. As a result the longer growing season cultivar, Scheepers 68, is grown in the West and the shorter season, Betta and SST102, in the East. Along with this goes the lower yield expectation in the West compared to the East and therefore a difference in the N recommendation. However, to confuse the issue a bit more the North Western Free State (Viljoenskroon, Bothaville, Wesselsbron) is capable of giving high yields, requiring more N.

A further factor causing confusion is that Scheepers 69, with its alledged weak straw, lodges in the North Western Free State at N rates of 40 to 50 kg/ha, but not in the Eastern Free State (Ficksburg).

Nitrogen

At the last consultation with the agronomy section of the Small Grain Centre the following rates of N in kg/ha for the different regions of the wheat producing areas were agreed upon (See Table 4).

TABLE 4: N recommendations for wheat in different areas

Region	kg N/ha
Swartland	15 - 45
Rûens	20
Orange Free State*	
Region 1	10 - 15
Region 2	20 - 40
Region 3	15 - 25
Region 4	20 - 40

* See the map of regions in Figure 1.

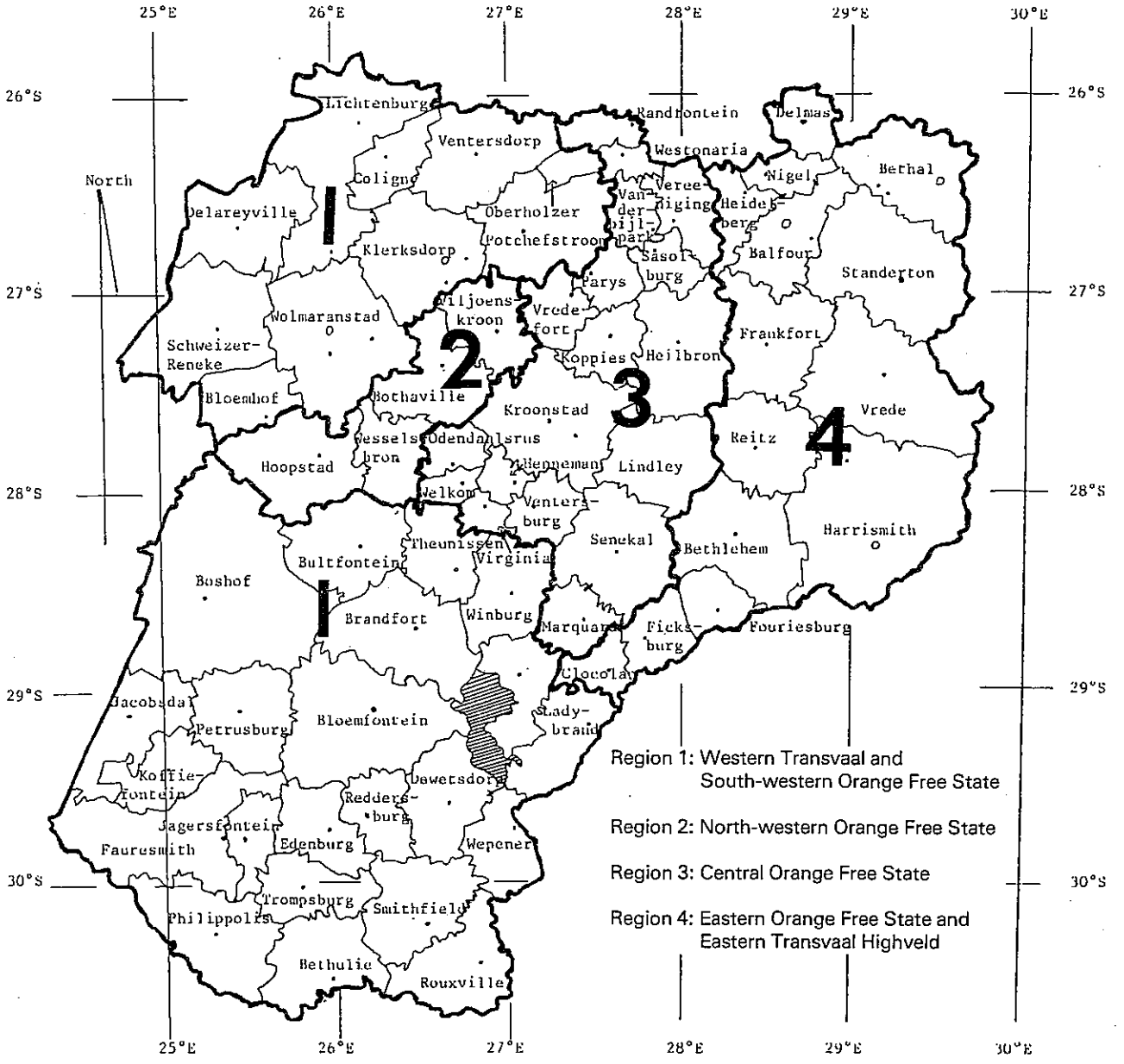

Fig 1: Wheat production areas in the summer rainfall region of the RSA, according to climate

Phosphorus

As far as P is concerned the agreed recommendation is as follows:

(i) Increase of soil P content to 35 mg/kg (Bray 1) (as in the case with maize it is assumed that on average 6,5 kg P/ha will increase the contents by 1 mg P/kg soil).

(ii) At P content of 35 mg/kg the requirements of P are 5 kg per ton expected yield.

(iii) For P contents lower than 35 mg/kg the following quantities are recommended for different yield potentials (Table 5):

These guidelines are preliminary and will have to be rectified by a more intensive study of the soil contents and yields obtained.

TABLE 5: P recommendations for wheat according to soil P and yield target, kg P/ha

mg P/Kg soil (Bray 1)	Yield target in ton/ha				
	1,0	1,5	2,0	2,5	3,0
10	15	21	28	36	45
20	10	14	18	22	27
30	7	9	12	14	17

Potassium

The effect of K is variable. Guidelines are not available. However, it is interesting to note that in many of the experiments the most economic yields were obtained where K was present.

A preliminary guideline, based on maize experiments (Venter, 1981) is presented (Table 6).

TABLE 6: Preliminary K recommendations for wheat, kg K/ha.

mg K/kg Soil	Yield target in ton/ha				
	1,0	1,5	2,0	2,5	3,0
60	10	15	20	25	30
60 - 100	6	6	10	13	15
100	0	0	0	10	10

Fertilization experiments

Cape

Experimental work in the Cape was started in 1981. The first year's results were encouraging. In the Swartland significant linear responses to N fertilization were obtained at Koeberg and Wellington, where the highest N level was 60 kg/ha and at Moorreesburg, where 45 kg/ha was the highest level:

Significant linear reactions to P were found at Koeberg and Moorreesburg (higher level 45 kg/ha). Before the start of the experiments the P content of the soils was 18 and 22 mg/kg (Bray 1) respectively.

In the Rûens there were no significant N responses, but P induced positive increases at all four locations (Caledon, Bredasdorp, Heidelberg and Swellendam). The P content of the soils ranged from 13 to 22 mg/kg.

The lack of response to N was expected as wheat is grown in rotation with legume pastures, which are established and maintained for a minimum period of three years.

Orange Free State

The effect of fertilization on th yield of Scheepers 69 obtained from experiments, which have been carried out for a period of three or more years, is shown in Table 7.

TABLE 7: Experiments with Scheepers 69

Season	District*	Yield 2. kg/ha	Optimum NPK kg/ha	Profit Income-Fertilizer cost. 3. R/ha
1978	Ficksburg	1559	30 15 0	339
	Kroonstad	2252	40 40 –	475
	Viljoenskroon	3986	60 40 –	877
1979	Ficksburg	2256	15 30 50	484
	Kroonstad	2827	60 40 –	598
	Viljoenskroon	2826	60 40 –	598
1980	Ficksburg	1695	50 20 50	334
	Kroonstad	1150	20 40 –	224
	Viljoenskroon	1444	60 40 –	267
1981	Fiksburg 1.	2562	50 40 100	504

(i) The rates at Ficksburg increased from N O, 15, 30 kg/ha, P O, 15, 30 kg/ha, K O, 25, 50 kg/ha in 1978 and 1979 to N O, 25, 50 kg/ha in 1978 and 1979 to N O, 25, 50 kg/ha, P O, 20, 40 kg/ha, K O, 50, 100 kg/ha. This was done as N showed a linear increase up to 30 kg/ha and no P or K reaction was found.

At Kroonstad and Viljoenskroon the rates remained unchanged N O, 20, 40, 60 kg/ha, P O, 20, 40 kg/ha.

(ii) The yields in this column were significantly higher than those of the control treatments.

(iii) The price of wheat and the cost of fertilizer for 1981 were used for the calculation of the profits.

The results presented in Table 7 show that in every case the most economic yields were obtained from interactions between elements (at Kroonstad and Viljoenskroon K was not included).

This happened, even where the main effect of one of the elements showed no yield increase due to that element, as was the case with P at Ficksburg (see Figure 2). A significant linear yield increase to P was only recorded in 1981, when the P content of the soil had risen from 18 mg/kg (before the start of the experiment) to 31 mg/kg, when the second level of P was applied.

K showed a significant quadratic effect in 1979 (see Figure 2).

At Kroonstad the average yields for the three seasons showed a curvilinear response to N and to P. From the regression formulae it was calculated that the point of maximum profit was reached with 33 kg N/ha and 24 kg P/ha.

At Viljoenskroon the N and P reactions were linear every season.

An interesting fact is that the price of fertilizer relative to wheat, as shown in Table 8, has become less expensive.

TABLE 8: Fertilizer cost in relation to wheat price

	1978	1979	1980	1981
	R/c			
300 kg/ha 3:2:2 (25) + Zn	41,27	47,31	55,80	59,23
Wheat price, R per ton kg wheat to pay for fertilizer	136	285	215	240
	303	256	260	247

Quality

The two main factors determining the quality of wheat flour for baking purposes are protein percentage and hℓ mass.

It is the intention to introduce a premium on wheat with a minimum protein in the kernel of 13 per cent. In the milling process approximately one per cent protein is lost because parts of the kernel containing protein are removed. Therefore the requirements of the Wheat Board will mean the presence of 12 per cent protein in the flour.

The protein content of the wheat grain is determined by weather conditions influencing yield and to a varying degree by nitrogen fertilization.

Scheepers 69 is notorious for its low protein percentage. In Table 9 the protein percentage in the flour, the hℓ mass and yield in kg/ha are given for the N levels applied in the four seasons 1978 — 1981 to the Ficksburg experiment.

TABLE 9: Wheat quality and nitrogen fertilization at Ficksburg, 1978 - 1981.

	Protein in flour %	hℓ mass kg/hl	Yield kg/ha
1978 NO	10,3	78,4	1215
N15	10,3	78,8	1300
N30	10,8	78,8	1433
1979 NO	7,7	75,6	1759
N15	7,8	75,3	1962
N30	8,4	74,5	2091
1980 NO	15,9	69,3	1240
N25	16,8	69,3	1290
N50	17,8	69,4	1481
1981 NO	10,5	79,3	2007
N25	10,8	78,8	2042
N50	12,1	78,4	2141

The hℓ mass is an indication of flour yields and determines the grade of wheat, according to which farmers are at present paid.

For Scheepers 69 the following grades are given:

hℓ mass	grade
76	1
72	2
68	3

The difference in price due to grade is substantial as can be seen in Table 10.

TABLE 10: Price of different grades of Scheepers 69

	Price per ton		
Grade	1	2	3
1978	132	126	114
1979	179	172	155
1980	209	199	176
1981	233	222	196

Only in 1980 was the protein percentage in the flour higher than 12, irrespective of the N level. However, the grain was shrivelled and due to poor rainfall conditions only made grade 3.

The whole picture of manipulating the quality of wheat grain is complicated. Results obtained in 1978 and 1980 illustrate this clearly. Although yields were almost identical, the protein content was considerably higher in 1978 than in 1980.

The only satisfactory grain was obtained with 50 kg N/ha in 1981, giving 12,1 per cent protein and a grade 1.

Future developments

In planning future developments cognisance will have to be taken of the fact that by the year 2000 South Africa will need 4 million tons of wheat for internal consumption. This will mean doubling present yields.

Management, which includes the proper control of all agronomic production factors, appears to be more critical in the case of wheat than maize. This is one fact which has emerged from the experimental work carried out. The reason is not quite clear, but even under conditions of adequate moisture supply, lack of control of, for instance partial weed- or insect infestations through oversight, could result in large differences in yield for the same treatment in different replications. Consequently the results become unreliable (high CV's) and interpretations and recommendations based thereon of dubious value. It is therefore maintained that a large portion of the fluctuation in wheat yields from season to season is the result of inadequate management.

Although steady progress has been made with regard to the knowledge of the beneficial effects of higher fertilizer levels than those applied on wheat yields, in 1978, there are still many grey areas. The path ahead is clear, but it has to be integrated with work on production factors other than fertilization. This cannot be the sole responsibility of the Fertilizer Society and multidisciplinary action will have to take place.

As far as work on fertilization is concerned the grey areas will have to be cleared up and here the priotities are clear cut:

(a) Short-term priorities

More detailed **guidelines for N, P and K** application under different climatic conditions to ensure maximum profits. This will have to include irrigation projects, as in many cases the yields are too low for an acceptable return on capital employed.

(b) Long-term priorities

(i) Better understanding of; plant/soil interactions, which will require plant- as well as soil **sampling;**

— **uptake of N, P and K** by the roots and the transport throught the plant to the kernel, and;

— the determination of **nitrogen reserves** in soils and the availability of these reserves to the plants throughout the growing period;

(ii) determination of the influence of weather conditions and fertilization (especially N) on the **quality characteristics** of wheat flour. This will have to be done in co-operation with the Wheat Board.

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